Cal/Ecotox
Exposure Factors for Bullfrog (Rana catesbeiana)*

Endpoint Type	Endpoint Value	Error	Range	Units	Sex	Life Stage	Location	Note	Reference
Age at Fledging, Metamorphosis, Weaning			6 - 7	mo	NR	NR	CA	a	1
Age at Fledging, Metamorphosis, Weaning			2 - 3	yr	B	Tadpole	NY	b	2
Age at Fledging, Metamorphosis, Weaning	1			yr	NR	Tadpole	KY	c	3
Age at Fledging, Metamorphosis, Weaning			3 - 6	mo	NR	Tadpole	AZ; CA	d	4
Age at Fledging, Metamorphosis, Weaning			13 - 16 or 24 - 25	mo	NR	Tadpole	MI	e	5
Age at Fledging, Metamorphosis, Weaning			24 - 27	mo	NR	Tadpole	IL	f	6
Age at Fledging, Metamorphosis, Weaning			12 - 14	mo	NR	Tadpole	KY	g	7
Age at Sexual Maturity			1 - 2	yr	F	Adult	MI	h	8
Age at Sexual Maturity	5			yr	F	Adult	CANADA	i	9
Age at Sexual Maturity	1			yr	M	Adult	MI	j	8
Age at Sexual Maturity	3			yr	M	Adult	CANADA	k	9
Age at Sexual Maturity			1 - 2	yr	NR	Adult	AZ; CA	l	4
Body Weight - Mean	0.52		0.46 - 0.57	lbs	NR		IL	m	6
Body Weight - Mean			0.01 - 0.10	lbs	NR		IL	n	6
Body Weight - Mean	0.46		0.33 - 0.56	lbs	NR		IL	o	6
Body Weight - Mean	0.02			lbs	NR		IL	p	6
Body Weight - Mean	0.64		0.55 - 0.76	lbs	NR		IL	q	6
Body Weight - Mean	0.80		0.68 - 0.91	lbs	NR		IL	r	6
Body Weight - Mean	0.58		0.53 - 0.62	lbs	NR		IL	s	6
Body Weight - Mean	175.9	8.16 SE		g	B	Adult	Lab	t	10
Body Weight - Mean			608 - 646	g	NR	Adult	Lab	u	11
Body Weight - Mean	142.8	77.4 SD	9.5 - 274.0	g	NR	Adult	CANADA	v	12
Body Weight - Mean	10.7		6.0 - 18.7	g	NR	Juvenile	Lab	w	13
Body Weight - Mean	29.8		18.5 - 51.6	g	NR	Juvenile	Lab	x	13
Body Weight - Mean	42.4		27.6 - 77.2	g	NR	Juvenile	Lab	y	13
Body Weight - Mean	17.5		13.1 - 41.6	g	NR	Juvenile	Lab	z	13
Body Weight - Mean	55.8		40.5 - 100.8	g	NR	Juvenile	Lab	aa	13
Body Weight - Mean			249 - 252	g	NR	NR	AR	ab	14
Body Weight - Mean			15 - 200	g	NR	NR	CA	ac	1
Body Weight - Mean	see citation			g	NR	Tadpole	KY	ad	3
Body Weight - Mean			7 - 43	g	NR	Tadpole	MI	ae	5
Body Weight - Mean			0.5 - 5.4	g	NR	Tadpole	KY	af	7
Body Weight - Mean			20 - 36	g	NR	Tadpole	KY	ag	7
Clutch or Litter Size	7,360	741.7 SE		#/egg mass	F	Adult	NJ	ah	15
Clutch or Litter Size			6,000 - 20,000	eggs/clutch	F	Adult	MI	ai	16
Clutches or Litters per year			1 - 2	clutches/yr	F	Adult	MI	aj	17
Clutches or Litters per year			1 - 2	clutches/yr	F	Adult	MI	ak	16
Dietary Composition	Review				B	Adult		al	18
Dietary Composition	Newly metamorphosed and larval Rana (87%), Aquatic snails (5%), Adult and larval aquatic Coleoptera (3%), Adult and larval Odonata (3%), Other (2%)				B	Adult	NM	am	19
Dietary Composition	crayfish (24%), wolf spiders (36%), long horned earwigs (20%), sowbugs (25%), german cockroaches (14%), crickets (16%), vascular plants (36%), inorganic material (12%), other animals (10%)				NR	Adult	AZ; CA	an	4

Endpoint Type	Endpoint Value	Error	Range	Units	Sex	Life Stage	Location	Note	Reference
Dietary Composition	see citation				NR	Adult	NY	ao	20
Dietary Composition	frogs (13.0%); shiners (27.5%); gastropods (16.1%); crayfish (16.3%); arachnida (4.5%); coleoptera adult (10.5%); hemiptera (13.5%); orthoptera (5.8%); lepidoptera larvae (4.5%); odonata adult (4.2%)			%	NR	Adult	MO	ap	21
Dietary Composition	frogs (12.1%); goldfish (30.3%); gastropods (12.4%); crayfish (9.3%); arachnida (4.4%); coleoptera adult (10.6%); hemiptera (8.2%); orthoptera (8.7%)			%	NR	Adult	MO	aq	21
Dietary Composition	Insecta (20.6%); Arachnida (4.8%); Amphibia (27.4%); Diploda (0.3%); Gastropoda (1.0%); Crustacea (4.3%);Teleosts (0.6%); Mammalia (5.0%); Oligochaeta (1.3%); Reptilia (6.4%); Pebbles and sand (8.0%); Vegetative material (12.3%); Digested material (7.3%)				B	Both Adult and Juv.	VA	ar	22
Dietary Composition	Insecta (51.8%); Arachnida (11.2%); Amphibia (2.8%); Diploda (1.3%); Gastropoda (1.3%); Crustacea (1.4%);Teleosts (1.1%); Mammalia (0.2%); Oligochaeta (1.3%); Reptilia (0.2%); Pebbles and sand (3.4%); Vegetative material (12.5%); Digested material (11.6%)				B	Both Adult and Juv.	VA	as	22
Dietary Composition	Coleoptera (2.3-6.5%), Wasps and bees (1.1-4.7%), Ants (0-3.5%), Homoptera (2.3-6.0%), Odonata (12.4-17.5%), Larval Lepidoptera (0.5-2.1%), Diptera (3.7-10.5%), Arachnids (0-3.2%), Miscellaneous terrestrial(10.5-11.1%), Hemiptera (19.2-23.2), Larval Odonata (3.4-5.0%), Larval Diptera (4.4-7.2%), Miscellaneous aquatic (1.9-7.4%), Frogs (5.1-14.5%), Metamorphosing Odonates (0-5.7%), Miscellaneous (1.8-7.3)				B	Both Adult and Juv.	MI	at	23
Dietary Composition	see citation				NR	NR	AR	au	14
Dietary Composition	Insecta (92.0%), Crustacea (13.7%), Arachnida (13.7%), Diploda (5.6%), Chilopoda (1.6%), Gastropoda (4.0%), Reptilia (3.2%), Amphibia (9.6%), Aves (1.6%), Osteichthyes (4.0%)				NR	NR	TX	av	24

Endpoint Type	Endpoint Value	Error	Range	Units	Sex	Life Stage	Location	Note	Reference
Dietary Composition	Coleoptera (43.6%), Notonectidae (10.3%), Diptera (6.6%), Hymenoptera (6.3%), Locustidae (6.0%), Ephemeroptera (4.3%), Gryllidae (4.3%), Protura (3.3%), Chironomidae (2.6%), Culicidae (2.0%), Lepidoptera (1.3%), Odonata (0.3%), Gerridae (0.3%), Mantidae (0.3%), Sepsidae (0.3%), Unidentified parts (21.3%), Decomposed tissue (18.0%), Spiders (16.0%), Rocks, grass, leaves (22.0%), Chitinous material (10%), Snails, Planorbid (9.0%), Frogs (5.6%), Snails, Physid (4.7%), Small fish (4.3%), Unknown vertebrates (2.3%), Tadpoles (1.3%), Salamander (1.0%), Feathers (1.0%), Worms (0.6%), Egg sack (0.3%), Rabbit pellet (0.3%), Peromyscus (0.3%)				NR	NR	CA	aw	1
Dietary Composition	Gastropoda (0.7%), Arachnida (0.2%), Crustacea (12.8%), Insecta (81.5%), Chilopoda (0.2%), Osteichthyes, Cyprinidae (8.7%), Ictaluridae (10.1%), Centrarchidae (2.9%), Amphibia (0.7%), Mammalia (0.5%)				NR	NR	OK	ax	25
Dietary Composition	Decapoda: Astacidae (47.7%); Lepidoptera (19.0%); Coleoptera: Lampryidae (5.8%); Chrysomelidae (5.8%); Carabidae (4.1%); Curculionidae (0.3%); Chilopoda (7.7%); sand, gravel (1.2%); unidentified (1%)			%	NR	NR	KY	ay	26
Food Ingestion Rate	3.3			%	NR	Juvenile	Lab	az	13
Food Ingestion Rate	5.9			%	NR	Juvenile	Lab	ba	13
Food Ingestion Rate	7.1			%	NR	Juvenile	Lab	bb	13
Food Ingestion Rate	4.0			%	NR	Juvenile	Lab	bc	13
Food Ingestion Rate	0.4			g	B	NR	VA	bd	22
Food Ingestion Rate	4.6			g	B	NR	VA	be	22
Food Ingestion Rate	2.33			g	B	NR	VA	bf	22
Growth Rate	0.1056	0.01427 SE		mm/d	B		CANADA	bg	9
Growth Rate	0.0653	0.01465 SE		mm/d	B		CANADA	bh	9
Growth Rate	0.1322	0.1109 SE		mm/d	F		CANADA	bi	9
Growth Rate	0.0930	0.02287 SE		mm/d	F		CANADA	bj	9
Growth Rate	0.1250	0.02155 SE		mm/d	F		CANADA	bk	9
Growth Rate	0.0466	0.02093 SE		mm/d	F		CANADA	bl	9
Growth Rate	0.0304	0.02256 SE		mm/d	F		CANADA	bm	9

Endpoint Type	Endpoint Value	Error	Range	Units	Sex	Life Stage	Location	Note	Reference
Growth Rate	0.0449	0.00996 SE		mm/d	F		CANADA	bn	9
Growth Rate	0.1353	0.01079 SE		mm/d	M		CANADA	bo	9
Growth Rate	0.0841	0.01882 SE		mm/d	M		CANADA	bp	9
Growth Rate	0.0697	0.03720 SE		mm/d	M		CANADA	bq	9
Growth Rate	-0.0043	0.33534 SE		mm/d	M		CANADA	br	9
Growth Rate	0.0038	0.01654 SE		mm/d	M		CANADA	bs	9
Growth Rate			5 - 20	mm/yr	B	Adult	MI	bt	8
Growth Rate	review				B	Adult; Tadpole		bu	27
Growth Rate	0.4			stages/d	NR	Tadpole	Lab	bv	28
Growth Rate	0.02			stages/d	NR	Tadpole	Lab	bw	28
Home Range	8.6		2.0 - 37.1	ft	B	Adult	CANADA	bx	29
Home Range			> 80 - 90	ft	NR	Adult	MO	by	30
Inhalation Rate	see citation				B	Adult	Lab	bz	10
Longevity			8 - 10	yr	B	Adult	CANADA	ca	9
Longevity			7-8	yr	NR	Adult	CA	cb	31
Longevity			5 - 8	yr	NR	Adult	MI	cc	32
Metabolic Rate	see citation				B	Adult	Lab	cd	10
Metabolic Rate	53.3	2.1 SE		ul O2/g/hr	NR	Adult	Lab	ce	11
Metabolic Rate	15.5	1.2 SE		ul O2/g/hr	NR	Adult	Lab	cf	11
Metabolic Rate	1.1	0.1 SE		umol O2/g/hr	NR	Adult	Lab	cg	33
Metabolic Rate	24.56		18.3 - 36.6	ul O2/g/hr		NR	Lab	ch	34
Metabolic Rate	17.02		5.3 - 39.4	ul O2/g/hr		NR	Lab	ci	34
Metabolic Rate	29.36		22.5 - 33.2	ul O2/g/hr		NR	Lab	cj	34
Metabolic Rate	27.74		22.5 - 33.2	ul O2/g/hr	NR	NR	Lab	ck	34
Metabolic Rate	178.2	36.7		ul O2/g/hr	NR	Tadpole	Lab	cl	35
Metabolic Rate	5.9	0.3 SE		umol O2/g/hr	NR	Tadpole	Lab	cm	33
Metabolic Rate	6.9	0.5 SE		umol O2/g/hr	NR	Tadpole	Lab	cn	33
Metabolic Rate	see citation				NR	Tadpole	Lab	co	36
Metabolic Rate	see citation			ul/g/hr	NR	Tadpole	Lab	cp	37
Metabolic Rate	0.1582	0.009 SE		ml O2/hr/tadpole	NR	Tadpole	Lab	cq	38
Population Density			8.3 - 12.8	#/1000 ft2	B	Adult	CANADA	cr	29
Population Density	9.1			#/linear river km	NR	Adult	AZ; CA	cs	4
Population Density	90.9	97.7 SD	0 - 310	#/m2	B	Tadpole	Mendocino; CA	ct	39
Population Density	18.2	13.1 SD	1 - 52	#/m2	B	Tadpole	Mendocino; CA	cu	39
Population Density			0.9 - 13.2	#/m2	NR	Tadpole	KY	cv	3
Surface Area	Log SA = 0.923 + (0.711Log BW)			cm2	NR	Adult	Lab	cw	40
Surface Area	SA = 0.953W^0.725			cm2	NR	NR		cx	34
Surface Area	15.09	0.85 SE		cm2	NR	Tadpole	Lab	cy	33
Survival/ Mortality	0.42				M		MI	cz	41
Survival/ Mortality			8 - 21	%	B	Adult	MI	da	8
Survival/ Mortality	0.23				M	Adult	MI	db	41

Endpoint Type	Endpoint Value	Error	Range	Units	Sex	Life Stage	Location	Note	Reference
Survival/ Mortality	0.52				M	Adult	MI	dc	41
Survival/ Mortality			11.8-17.6	%	NR	Tadpole	KY	dd	3
Territory Size	17.8	5.9 SD		ft	M	Adult	MI	de	42
Territory Size	4.1			m	M	Adult	NJ	df	15
Time of Fledging or Metamorphosis	Review				B	Tadpole		dg	18
Time of Fledging or Metamorphosis	July - Oct.				B	Tadpole	NY	dh	2
Time of Fledging or Metamorphosis	July - Sept.				NR	Tadpole	KY	di	3
Time of Fledging or Metamorphosis	Aug. - Oct.				NR	Tadpole	AZ; CA	dj	4
Time of Fledging or Metamorphosis	Aug. - Oct. or Mar. - Apr. of following yr.				NR	Tadpole	AZ; CA	dk	4
Time of Fledging or Metamorphosis	July - Sept.				NR	Tadpole	MI	dl	5
Time of Fledging or Metamorphosis	June (begin), July - Aug. (peak), Oct. (end)				NR	Tadpole	KY	dm	7
Time of Fledging or Metamorphosis	May (begin), July-Aug. (peak), Oct. (end)				NR	Tadpole	MO	dn	30
Time of Mating/ Laying	Review				B	Adult		do	18
Time of Mating/ Laying	May - June				F	Adult	IL	dp	6
Time of Mating/ Laying	Apr - June				F	Adult	NJ	dq	15
Time of Mating/ Laying	May (begin), June (peak), Aug. (end)				F	Adult	MO	dr	30
Time of Mating/ Laying	July				F	Adult	Mendocino; CA	ds	39
Time of Mating/ Laying	early Apr. (begin), late Apr. - early May and late May - early June (peaks), July (end)				NR	Adult	AZ; CA	dt	4
Time of Torpor or Hibernation	Oct. - Mar.				NR	Adult	MO	du	30
Time of Torpor or Hibernation	Oct. - April				NR	Adult	OH	dv	43
Time of Torpor or Hibernation	Oct. - Mar.				NR	Tadpole	IL	dw	6
Water Ingestion Rate	0.18	0.02 SE		ml/100 g/hr	NR	Tadpole	Lab	dx	44

Notes

a time to complete from egg through metamorphosis; N=300; San Joaquin Experimental Range, O'Neals

b N=NR; Ithaca

c N=NR; Coldstream Pond and Fred Pond, northeast of Lexington, [38o06'23"N, 84o30'08"W]

d time to metamorphosis from first breeding clutch; N=NR; lower Colorado River between Laguna and Morelos Dams

e Referred to as "age at transformation"; range of snout-vent length at transformation = 35-57 mm; N=1051; Crane Pond, E.S. George Reserve, Livingston County [lat., 42.5N]; See paper for review of larval life history characteristics as a function of latitude

f N=NR; Ridge Lake, Charleston, Coles County

g Time to transformation after hatching from eggs; N=3500; ponds, University of Kentucky, Lexington [lat.,38^o06'23"N; long., 84^o30'08"W]

h age after metamorphosis when produced eggs; N=NR; Crane Pond, E.S. George Reserve

i Average age at maturity, measured in years post-transformation; N=567; Algonquin Provincal Park, Ontario [lat., 45^o35'N; long., 78^o30'W]

j age after metamorphosis; development of secondary sex characteristics; N=NR; Crane Pond, E.S. George Reserve

k Average age at maturity, measured in years post-transformation; N=567; Algonquin Provincal Park, Ontario [lat., 45^o35'N; long., 78^o30'W]

l N=NR; lower Colorado River between Laguna and Morelos Dams

m N=5; Age=end of 3rd yr; Ridge Lake, Charleston, Coles County

n N=5-13; Age=during 1st yr; May - Aug.; Ridge Lake, Charleston, Coles County

o N=5; Age=end of 2nd yr; Ridge Lake, Charleston, Coles County

p at metamorphosis; N=48; Age=at metamorphosis; Ridge Lake, Charleston, Coles County

q N=6; Age=end of 5th yr; Ridge Lake, Charleston, Coles County

r	N=5; Age=end of 6th yr; Ridge Lake, Charleston, Coles County
s	N=3; Age=end of 4th yr; Ridge Lake, Charleston, Coles County
t	N=30
u	range of mean body weights; N=8
v	N=39; Apr. - Sept.; York County, New Brunswick [lat., 45^o47'; long., 66^o37']
w	N=25; Age=newly transformed
x	N=25; Age=2 mo post-transformation
y	N=25; Age=3 mo post-transformation
z	N=25; Age=1 mo post-transformation
aa	N=25; Age=4 mo post-transformation
ab	range of mean body weights; N=29 - 62; Mar. - June; streams, ponds, strip pits in Pulaski, Loanoke and Saline counties
ac	N=300; San Joaquin Experimental Range, O'Neals
ad	figure of annual variation in weight; N=27 - 1817; Coldstream Pond and Fred Pond, northeast of Lexington, [38o06'23"N, 84o30'08"W]
ae	See paper for weight to developmental stage relationship (Gosner stages 27-40); N=120; May; Crane Pond, E.S. George Reserve, Livingston County [lat., 42.5N]; See paper for annual variation in body size at metamorphosis
af	Range of means; N=41 - 194; Age=Taylor-Kollros stages II - IX; July - Oct.; ponds, University of Kentucky, Lexington [lat.,38^o06'23"N; long., 84^o30'08"W]; See citation for complete stage to weight relationship
ag	Range of means; N=23 - 235; Age=Taylor-Kollros stages XVIII - XXI; July - Aug.; ponds, University of Kentucky, Lexington [lat.,38^o06'23"N; long., 84^o30'08"W]; See citation for complete stage to weight relationship
ah	Number of eggs in a 10x10cm area used to estimate eggs per mass; N=36; April - June; Basking Pond, Great Swamp National Wildlife Refuge, Morris County
ai	N=NR; June - July; Crane Pond, E.S. George Reserve
aj	Double clutching observed in 5 out of 73 females; N=73; May - June
ak	N=NR; Crane Pond, E.S. George Reserve
al	N=NR; Reviews literature on foods of adult bullfrogs
am	Total percent volume of stomach contents, frog snout-vent length range = 90 - 190 mm; N=138; July; Wall Lake, southeast Catron County
an	% frequency of occurence in stomach contents; N=100; July - Sept.; lower Colorado River between Laguna and Morelos Dams
ao	% frequency of 26 food items in stomach contents (family level); N=24; July; Cranberry Lake Biological Station, Barber Point, Cranberry Lake
ap	% of stomachs containing major (>4%) food items; N=553; yr-round; bait minnow pond, Richland; see citation for detailed list of prey items and seasonal changes in diet
aq	% of stomachs containing major (>4%) food items; N=772; yr-round; goldfish pond, Richland; see citation for detailed list of prey items and seasonal changes in diet
ar	% weight of an item; obtained by dividing the weight of a specific item by the total weight of all items; obtained from stomach contents; N=129; June - Nov.; ponds, Hanover County; % weight should be regarded with caution as it may represent a fraction of the weight of the specimen eaten. Mean weight of gut contents = 1.53 g
as	% occurrence of item; obtained by dividing # of a specific item taken by total # of items; based on stomach contents; N=129; June - Nov.; ponds, Hanover County; see citation for seasonal and body size variation in dietary composition
at	Percentage of bullfrog diet items; N=23-46; June - Aug.; Turkey Marsh, Kellogg Biological Station, Kalamazoo County; See paper for relationship between prey size and frog snout-vent length
au	% occurrence of 44 food items in stomach contents (species level); N=139; Mar. - June; streams, ponds, strip pits in Pulaski, Loanoke and Saline counties
av	Percent occurrence in stomach contents from frogs collected during day and night; N=124; ponds in north central TX
aw	% of stomachs in which food item was present at least once, frog weight range 10 - 200 g; N=300; San Joaquin Experimental Range, O'Neals; See paper for length to weight relationship
ax	Percent stomachs containing item; N=415; June - Nov.; ponds, Comanche and Kiowa counties
ay	% volume of stomach contents; N=18; summer; Breathitt and Perry counties
az	mean % body weight consumed per day, body weight mean = 55.8 g; N=25; Age=4 mo post-transformation; frogs fed a 1:1:1 mixture of mosquitofish, crickets and earthworms
ba	mean % body weight consumed per day, body weight mean = 29.8 g; N=25; Age=2 mo post-transformation; Frogs fed a 1:1:1 mixture of mosquitofish, crickets and earthworms
bb	mean % body weight consumed per day, body weight mean = 17.5 g; N=25; Age=1 mo post-transformation; Frogs fed a 1:1:1 mixture of mosquitofish, crickets and earthworms
bc	mean % body weight consumed per day, body weight mean = 42.4 g; N=25; Age=3 mo post-transformation; Frogs fed a 1:1:1 mixture of mosquitofish, crickets and earthworms
bd	average weight of stomach contents for frogs with an average body weight of 17.5 g; N=78; June - Nov.; ponds, Hanover County
be	average weight of stomach contents for frogs with an average body weight of 248.7 g; N=18; June - Nov.; ponds, Hanover County
bf	average weight of stomach contents for frogs with an average body weight of 106.3 g; N=42; June - Nov.; ponds, Hanover County
bg	N=34; Age=1 yr; Algonquin Provincal Park, Ontario [lat., 45^o35'N; long., 78^o30'W]
bh	N=16; Age=0 yr; Algonquin Provincal Park, Ontario [lat., 45^o35'N; long., 78^o30'W]
bi	N=44; Age=2 yr; Algonquin Provincal Park, Ontario [lat., 45^o35'N; long., 78^o30'W]
bj	N=14; Age=3 yr; Algonquin Provincal Park, Ontario [lat., 45^o35'N; long., 78^o30'W]
bk	N=10; Age=4 yr; Algonquin Provincal Park, Ontario [lat., 45^o35'N; long., 78^o30'W]
bl	N=4; Age=6 yr; Algonquin Provincal Park, Ontario [lat., 45^o35'N; long., 78^o30'W]
bm	N=4; Age=7 yr; Algonquin Provincal Park, Ontario [lat., 45^o35'N; long., 78^o30'W]

bn	N=5; Age=5 yr; Algonquin Provincal Park, Ontario [lat., 45^o35'N; long., 78^o30'W]
bo	N=46; Age=2 yr; Algonquin Provincal Park, Ontario [lat., 45^o35'N; long., 78^o30'W]
bp	N=12; Age=3 yr; Algonquin Provincal Park, Ontario [lat., 45^o35'N; long., 78^o30'W]
bq	N=7; Age=4 yr; Algonquin Provincal Park, Ontario [lat., 45^o35'N; long., 78^o30'W]
br	N=4; Age=5 yr; Algonquin Provincal Park, Ontario [lat., 45^o35'N; long., 78^o30'W]
bs	N=4; Age=6 yr; Algonquin Provincal Park, Ontario [lat., 45^o35'N; long., 78^o30'W]
bt	N=22; Crane Pond, E.S. George Reserve; See paper for growth rate vs. body length relationship
bu	see citation for review of growth rates based on size estimates; N=NR
bv	measured at 25C; Taylor-Kollros stages; N=11-14; Age=Taylor-Kollros stages 10-22; June - Aug.; see citation for temporal changes in body weights and effect of photoperiod on growth rate
bw	measured at 25C; Taylor-Kollros stages; N=11-14; Age=Taylor-Kollros stages 10-22; Nov. - Dec.; see citation for temporal changes in body weights and effect of photoperiod on growth rate
bx	mean activity radius; median = 7.2 ft; mode = 5.0-5.9 ft; N=131; Aug. - Sept.; pond at Go Home Bay, Ontario [lat.,45N; long., 79^o59'W]
by	distance of pond shoreline used; N=31; June - Sept.; farm ponds, Boone County; See citation for notes on occasional (<8% of frogs) pond to pond movement (distance traveled, 0.1 - 0.75 miles).
bz	figure of breathing frequency (breaths/min) at various seasons, temperatures and oxygen levels; N=6/group
ca	Maximum estimated age; N=567; Algonquin Provincal Park, Ontario [lat., 45^o35'N; long., 78^o30'W]
cb	N=NR
cc	N=NR; Edwin S. George Reserve, Ann Arbor
cd	figure of oxygen consumption at various body temperatures within seasons; N=6/group
ce	Oxygen consumption measured at 20C, frogs acclimated at 20C, mean body weight = 621 g (30.5 SE); N=8; See citation for relationship between temperature and oxygen consumption
cf	Oxygen consumption measured at 5C, frogs acclimated at 5C, mean body weight = 646 g (25.5 SE); N=8; See citation for relationship between temperature and oxygen consumption
cg	Mean total oxygen uptake at 20C (summed from skin and lung uptake), body weight = 228.2 g +/- 70.3 SE; N=6; See paper for carbon dioxide exchange rates
ch	Cutaneous oxygen uptake at 5C; N=9
ci	Pulmonary oxygen uptake at 5C; N=9
cj	Pulmonary oxygen uptake at 15C; N=4; See citation for relationship between oxygen uptake, body weight and temperature
ck	Cutaneous oxygen uptake at 15C; N=4; See citation for relationship between oxygen uptake, body weight and temperature
cl	Mean total oxygen uptake (skin + gills + lungs) measured at 25C, tadpole mean body weight = 5.74 g; N=5; See paper for ralationship between body size, temperature and oxygen uptake
cm	Mean total oxygen uptake at 20C (summed from skin and gill uptake), aquatic tadpole (stage IV-V) body weight = 3.6 g +/- 1.03 SE; N=6; See paper for carbon dioxide exchange rates
cn	Mean total oxygen uptake at 20C (summed from skin and gill/lung uptake), air-breathing tadpole (stage XVI-XIX) body weight = 5.3 g +/- 1.2 SE; N=8; See paper for carbon dioxide exchange rates
co	figures of aerial activity oxygen consumption and body weights at different developmental stages; N=59
cp	figures of oxygen consumption of submerged tadpoles measured at various oxygen tensions and pre-metamorphic stages; N=10/group
cq	resting oxygen consumption at 23C; N=19; tadpoles (mean body weight = 1.96 g) collected from a reference site
cr	N=131; Aug. - Sept.; pond at Go Home Bay, Ontario [lat.,45N; long., 79^o59'W]
cs	mean density measured on both banks of river; N=3 visual counts; July - Sept.; lower Colorado River between Laguna and Morelos Dams; see citation for snout-vent length frequency diagrams (159 frogs, 45-180 mm) and influence of vegetation on population density
ct	N=20 quadrats; Age="overwintered" tadpoles; July; Angelo Coast Range Reserve [lat., 39^o44'N; long., 123^o39'W]
cu	N=17 quadrats; Age="overwintered" tadpoles; June; Angelo Coast Range Reserve [lat., 39^o44'N; long., 123^o39'W]
cv	N=3 sampling periods, 20,000 animals; Coldstream Pond and Fred Pond, northeast of Lexington, [38o06'23"N, 84o30'08"W]
cw	SA = Total Surface Area in cm2; BW = body weight in grams wet weight; Log base 10; surface area estimated from removed skin of frogs ranging from 40 - 442 g; N=16
cx	Area of removed skin measured, equation based on weight (W) in grams; N=NR; See citation for graphical representation of data
cy	Mean total skin surface area measured by removing skin; air-breathing tadpole body weight 4.48 g +/- 0.31 SE; N=20
cz	probability of survival (age x-1 to age x); N=NR; Age=2 or 3 yrs; Edwin S. George Reserve
da	Non-breeding season survival; measured as # that returned to breed/# known to be alive at end of previous breeding season; N=25 - 54; Crane Pond, E.S. George Reserve
db	probability of survival (age x-1 to age x); N=NR; Age=5 yrs; Edwin S. George Reserve
dc	probability of survival (age x-1 to age x); N=NR; Age=4 yrs; Edwin S. George Reserve
dd	Range of mean survival of larvae; N=3 sampling periods, 20,000 animals; Nov. - July; May - Aug.; Sept. - June; Coldstream Pond and Fred Pond, northeast of Lexington, [38o06'23"N, 84o30'08"W]
de	Average distance between male frog and closest male neighbor within a chorus; also reported as a minimum territory radius of 9 ft.; N=94; June; Pond in E.S. George Reserve
df	Mean distance between territorial males; N=31; May; Basking Pond, Great Swamp National Wildlife Refuge, Morris County
dg	N=NR; Reviews time to transformation of bullfrog tadpoles
dh	N=NR; Ithaca
di	N=NR; Coldstream Pond and Fred Pond, northeast of Lexington, [38o06'23"N, 84o30'08"W]

dj	metamorphosis period for first breeding clutch; N=NR; lower Colorado River between Laguna and Morelos Dams
dk	time to metamorphosis for second clutch; N=NR; lower Colorado River between Laguna and Morelos Dams
dl	N=NR; Crane Pond, E.S. George Reserve, Livingston County [lat., 42.5N]; See paper for annual variation in percentage in metamorphic climax
dm	Tadpole transformation determined by presence of Taylor-Kollros stages XIX - XXIV; N=3500
dn	N=NR; farm ponds, Boone County
do	N=NR; Reviews breeding season of bullfrogs
dp	N=NR; Ridge Lake, Charleston, Coles County
dq	N=36; May; Basking Pond, Great Swamp National Wildlife Refuge, Morris County
dr	Measured as examining percentage of females with gonads in different developmental stages; N=350; farm ponds, Boone County
ds	laying; N=NR; Angelo Coast Range Reserve [lat., 39^o44'N; long., 123^o39'W]
dt	breeding season; N=100; lower Colorado River between Laguna and Morelos Dams
du	N=NR; farm ponds, Boone County
dv	N=6; Seiberling Naturealm, Summit County; see citation for overwintering activity monitoring via radiotelemetry
dw	N=NR; Ridge Lake, Charleston, Coles County
dx	"drinking" measured as 125I-iothalamate uptake in gut after 2 hrs; N=8

References

1 Cohen, Nathan W. and Walter E. Howard. 1958. Bullfrog food and growth at the San Joaquin Experimental Range, California. Copeia. 1958:223-225.

2 Ryan, Richard A. 1953. Growth rates of some ranids under natural conditions. Copeia. 1953(2):73-80.

3 Cecil, Stephen G. and John J. Just. 1979. Survival rate, population density and development of a naturally occurring anuran larvae (Rana catesbeiana). Copeia. 1979:447-453.

4 Clarkson, Robert W. and James C. deVos, Jr. 1986. The bullfrog, Rana catesbeiana Shaw, in the lower Colorado River, Arizona-California. J. Herpetol. 20:42-49.

5 Collins, James P. 1979. Intrapopulation variation in the body size at metamorphosis and timing of metamorphosis in the bullfrog. Ecology. 60(4):738-749.

6 Durham, Leonard and George W. Bennett. 1963. Age, growth, and homing in the bullfrog. J. Wildl. Manage. 27:107-123.

7 Viparina, Sally and John J. Just. 1975. The life period, growth and differentiation of Rana catesbeiana larvae occurring in nature. Copeia. 1975:103-109.

8 Howard, Richard D. 1981. Sexual dimorphism in bullfrogs. Ecology. 62(2):303-310.

9 Shirose, L.J., R.J. Brooks, J.R. Barta and S.S. Desser. 1993. Intersexual differences in growth, mortality, and size at maturity in bullfrogs in central Ontario. Can. J. Zool. 71(12):2363-2369.

10 Rocha, Priscila L. and Luiz G.S. Branco. 1998. Seasonal changes in the cardiovascular, respiratory and metabolic responses to temperature and hypoxia in the bullfrog Rana catesbeiana. J. Exp. Biol. 201:761-768.

11 Weathers, Wesley W. 1976. Influence of temperature acclimation on oxygen consumption, haemodyamics and oxygen transport in bullfrogs. Aust. J. Zool. 24:321-330.

12 McAlpine, Donald F. and Timothy G. Dilworth. 1989. Microhabitat and prey size among three species of Rana (Anura: Ranidae) sympatric in eastern Canada. Can. J. Zool. 67:2244-2252.

13 Modzelewski, Edward H., Jr, and Dudley D. Culley, Jr. 1974. Growth responses of the bullfrog, Rana catesbeiana, fed various live foods. Herpetologica. 30(4):396-405.

14 McKamie, J.A. and G.A. Heidt. 1974. A comparison of spring food habits of the bullfrog, Rana catesbeiana, in three habitats of central Arkansas. Southwest. Nat. 19(1):107-111.

15 Ryan, Michael J. 1980. The reproductive behavior of the bullfrog (Rana catesbeiana). Copeia. 1980:108-114.

16 Howard, Richard D. 1978. The influence of male-defended oviposition sites on early embryo mortality in bullfrogs. Ecology. 59(4):789-798.

17 Emlen, Stephen T. 1977. "Double clutching" and its possible significance in the bullfrog. Copeia. 1977(4):749-751.

18 Bury, R. B. and J.A. Whelan. 1984. Ecology and management of the bullfrog. Washington D.C.: U.S. Department of Interior, Fish and Wildlife Service, Resource Publication No. 155. 23 p.

19 Stuart, James N. and Charles W. Painter. 1993. Rana catesbeiana (bullfrog) cannibalism. Herpetologica. 24(3):103.

20 Stewart, Margaret M. and Peggy Sandison. 1972. Comparative food habits of sympatric mink frogs, bullfrogs, and green frogs. J. Herpetol. 6(3/4):241-244.

21 Corse, Wayne A. and Dean E. Metter. 1980. Economics, adult feeding and larval growth of Rana catesbeiana on a fish hatchery. J. Herpetol. 14:231-238.

22 Brooks, G. R., Jr. 1964. An analysis of the food habits of the bullfrog by body size, sex, month, and habitat. Va. J. Sci. 15:173-186.

23 Werner, Earl E., Gary A. Wellborn and Mark A. McPeek. 1995. Diet composition in postmetamorphic bullfrogs and green frogs: implications for interspecific predation and competition. J. Herpetol. 29(4):600-607.

24 Carpenter, H. L. and Morrison, E. O. 1973. Feeding behavior of the bullfrog, Rana catesbeiana, in north central Texas. Bios. 44:188-193.

25 Tyler, Jack. D. and Roger D. Hoestenbach, Jr. 1979. Differences in food of bullfrogs (Rana catesbeiana) from pond and stream habitats in southwestern Oklahoma. Southwest. Nat. 24(1):33-38.

26 Bush, Francis M. 1959. Foods of some Kentucky herptiles. Herpetologica. 15:73-77.

27 Turner, F.B. 1960. Postmetamorphic growth in anurans. Am. Midl. Nat. 64:327-338.

28 Crawshaw, Larry I.; Richard N. Rausch; Lonnie P. Wollmuth and Ethan J. Bauer. 1992. Seasonal rhythms of development and temperature selection in larval bullfrogs, Rana catesbeiana Shaw. Physiol. Zool. 65(2):346-359.

29 Currie, William and Edward D. Bellis. 1969. Home range and movements of the bullfrog, Rana catesbeiana (Shaw), in an Ontario pond. Copeia. 1969:688-692.

30 Willis, Yuell L., Don L. Moyle, and Thomas S. Baskett. 1956. Emergence, breeding, hibernation, movements and transformation of the bullfrog, Rana catesbeiana, in Missouri. Copeia. 1956:30-41.

31 Storer, Tracy I. 1922. The eastern bullfrog in California. Calif. Fish Game. 8:219-224.

32 Howard, Richard D. 1978. The evolution of mating strategies in bullfrogs, Rana catesbeiana. Evolution. 32(4):850-874.

33 Burggren, Warren W., and Nigel H. West. 1982. Changing respiratory importance of gills, lungs and skin during metamorphosis in the bullfrog Rana catesbeiana. Respir. Physiol. 47:151-164.

34 Hutchinson, Victor H., W.G. Whitford and M. Kohl. 1968. Relation of body size and surface area to gas exchange in anurans. Physiol. Zool. 41:65-85.

35 Burggren, Warren W., Martin E. Feder, and Alan W. Pinder. 1983. Temperature and the balance between aerial and aquatic respiration in larvae of Rana berlandieri and Rana catesbeiana. Physiol. Zool. 56(2):263-273.

36 Hillman, Stanley S. and Malcom S. Lea. 1983. Aerial activity oxygen consumption during metamorphosis of the bullfrog, Rana catesbeiana. Copeia. 1983(2):407-410.

37 Crowder, William C., Minghua Nie and Gordon R. Ultsch. 1998. Oxygen uptake in bullfrog tadpoles (Rana catesbeiana). J. Exp. Zool. 280:121-134.

38 Rowe, Christopher L., Owen M. Kinney, Roy D. Nagle and Justin D. Congdon. 1998. Elevated maintenance costs in an anuran (Rana catesbeiana) exposed to a mixture of trace elements during the embryonic and early larval periods. Physiol. Zool. 71:27-35.

39 Kupferberg, Sarah J. 1997. Bullfrog (Rana catesbeiana) invasion of a California river: the role of larval competition. Ecology. 78:1736-1751.

40 Talbot, Colleen R. and Martin E. Feder. 1992. Relationships among cutaneous surface area, cutaneous mass, and body mass in frogs: A reappraisal. Physiol. Zool. 65(6):1135-1147.

41 Howard, Richard D. 1984. Alternative mating behaviors of young male bullfrogs. Am. Zool. 24:397-406.

42 Emlen, Stephen T. 1968. Territoriality in the bullfrog. Copeia. 1968(2):240-243.

43 Stinner, John, Nicholas Zarlinga and Scott Orcutt. 1994. Overwintering behavior of adult bullfrogs, Rana catesbeiana, in northeastern Ohio. Ohio J. Sci. 94(1):8-13.

44 Bentley, P.J. and T. Yorio. 1979. Do frogs drink?. J. Exp. Biol. 79:41-46.